

**Report Synopsis
Southwest Coastal Louisiana Feasibility Study
October 2013**

NOTE FOR READERS: This document provides an overview of planning work performed for two separate study authorities. Although overlapping and inter-related, the authorized investigation purposes are distinct. Parts of the planning work common to both evaluations are presented together. Other evaluations are presented separately to assist in presenting a complete analysis and improve readability.

1.0 Stage of Planning Process

This is a legacy feasibility study that is in Planning Step 6: Selecting a Recommended Plan. A Feasibility Scoping Meeting (FSM) was held on June 22, 2010. Comment responses were provided by the MVN Commander on September 10, 2010. The FSM was formally closed out on May 29, 2013. The Alternatives Milestone was approved on June 19, 2013.

2.0 Study Authority

The study has both National Economic Development (NED) and National Ecosystem Restoration (NER) components. This stems from two separate Congressional authorizations.

The NED purpose was authorized for the Southwest Coastal Louisiana Feasibility Study following the impact of Hurricane Rita in 2005.

“Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, that, in accordance with Section 110 of the River and Harbor Act of 1962, the Secretary of the Army is requested to survey the coast of Louisiana in Cameron, Calcasieu, and Vermilion Parishes with particular reference to the advisability of providing hurricane protection and storm damage reduction and related purposes to include the feasibility of constructing an armored 12-foot levee along the Gulf Intracoastal Waterway.” (December 7, 2005 – Committee on Transportation and Infrastructure, U.S. House of Representatives, Resolution Docket 2747, Southwest Coastal Louisiana)

Investigating the NER purpose was recommended in the 2005 Chief’s Report for the Louisiana Coastal Area (LCA) Ecosystem Restoration Program. The Chenier Plain Freshwater and Sediment Management and Allocation Reassessment Study was one of six large-scale restoration concepts that were purported to have the ability to “significantly restore environmental conditions that existed prior to large-scale alteration of the natural ecosystem” upon construction. The LCA program was authorized in Title VII of the Water Resources Development Act of 2007 (WRDA 2007).

2.1 Additional Study Guidelines

Section 5007 of WRDA 2007. Expedited Completion of Reports and Construction for Certain Projects. Guidance provided by the Director of Civil Works on December 19, 2008 states that *the coastal restoration components proposed as part of the LCA Chenier Plain study will be evaluated as part of the Southwest Coastal Louisiana feasibility study.*

MVD issued a policy guidance memo in June 2011 directing that “vertical accretion be included in the development of the FWOP condition as the most reasonable forecast of future conditions” and that “(t)he PDT should consult with the surge modeling experts at ERDC for advice on how to expeditiously incorporate vertical accretion into the existing H&H analysis of the FWOP condition for the study.”

2.2 Study Area

The area is located in southwestern Louisiana and covers over 4,700 square miles (see Figure 1). It occupies a portion of the Pleistocene Prairie Terrace (or Prairie Complex) on the northern edge of Cameron and Vermilion parishes, as well as most of Calcasieu Parish, and most of the Chenier Plain on the coast in Cameron and the southern portions of Calcasieu and Vermilion parishes. The major physiographic divisions in the area today are the Gulf Coast Prairies to the north and the Gulf Coast Marsh to the south, the latter of which is comprised of marsh interspersed with thin sand- and shell-rich ridges known as cheniers. The Gulf Intracoastal Waterway (GIWW) crosses the area generally coterminous with the state's coastal zone boundary. Other channels and waterways are oriented generally north to south and provide access to large interior tidal lakes and the Gulf of Mexico.

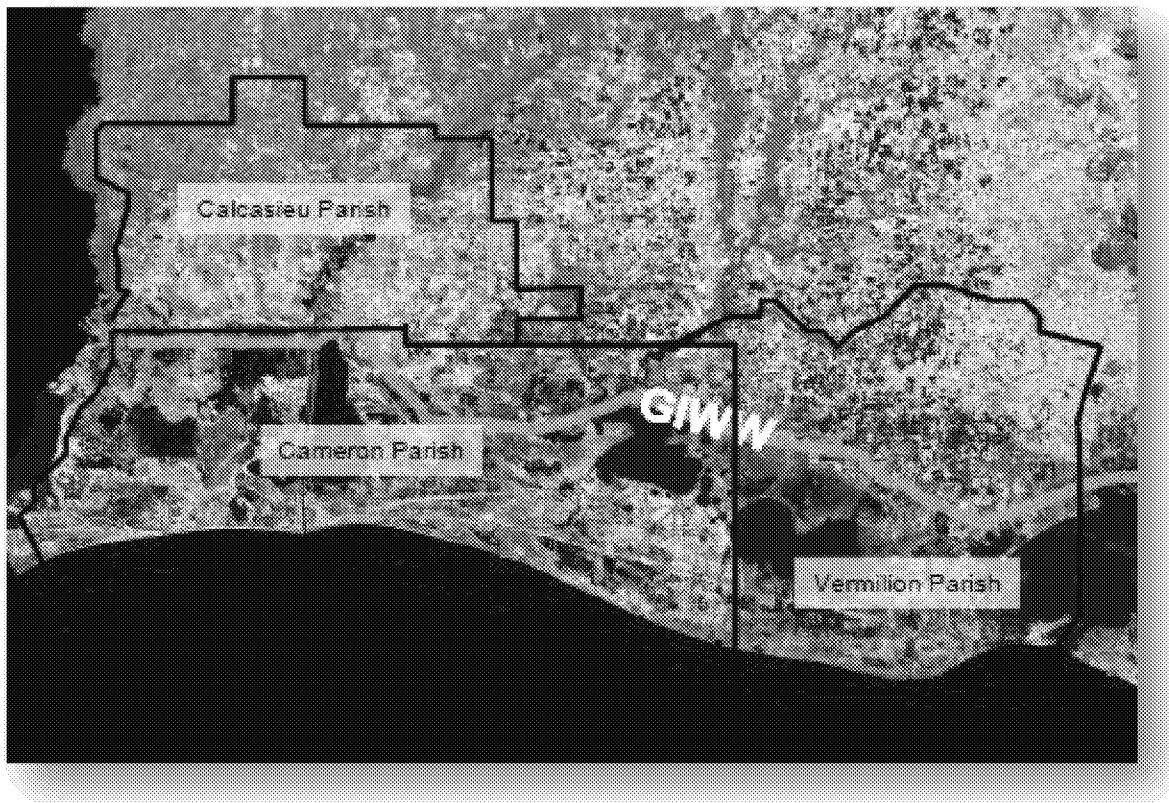


Figure 1. Study Area.

The two major hydrologic basins in the area are the Mermentau River and Calcasieu-Sabine Lakes (LCA 2004). The Teche/Vermilion Basin is another significant hydrologic basin in the area. The dominant hydrologic features are the Calcasieu, Sabine, Neches, Mermentau and Vermilion rivers as well as Calcasieu, Sabine, Grand, and White Lakes. Man-made channels include the Sabine-Neches Waterway, Calcasieu Ship Channel, GIWW, Mermentau Ship Channel, and Freshwater Bayou Canal Navigational Channel. The GIWW is the longest of these channels that have impacted the area's hydrology. Various water control structures in the area include the Calcasieu and Leland Bowman Locks, the Freshwater Bayou Canal Lock, the Schooner Bayou Canal Structure, and the Catfish Point Control Structure. The Gulf of Mexico coastline is another major water resource of the area. The major highways are LA Highway 82 and LA Highway 27. Population centers include many small towns, the largest of which are Lake Charles, Sulphur, and Abbeville. Figure 2 shows major water features and communities that the most part, fall within the coastal zone below the GIWW.

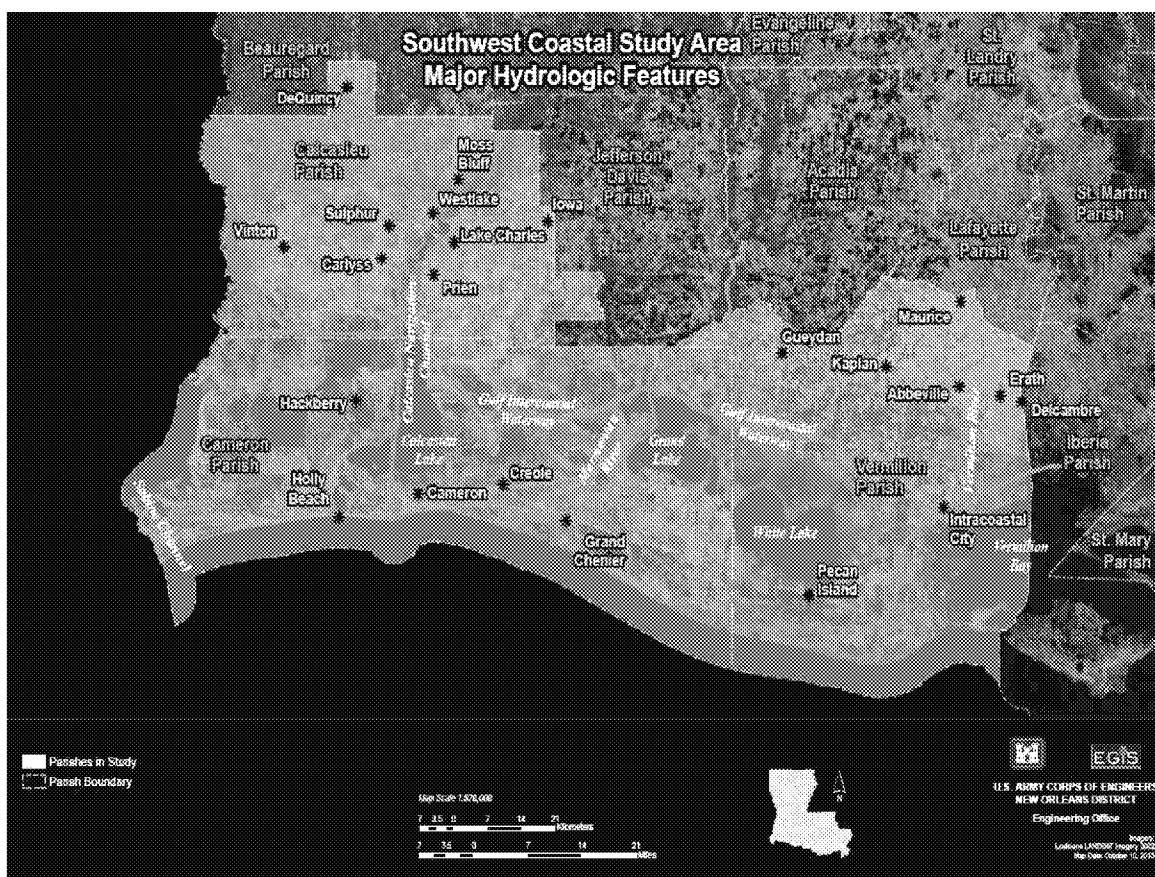


Figure 2. Major Water Features and Communities.

2.3 Project Area

The project areas are different for the two purposes. The NED project area concentrated on the areas north of the GIWW, but considered risk reduction measures for all structures at risk of flooding. The NER project area consists of the coastal zone, identified roughly as the areas south of the GIWW. Subunits were identified for the NED work and for the NER work to facilitate analysis on a manageable scale. Two types of subunits were identified: (1) hydrologic subunits, which are defined by similar surge elevations, and (2) ecologic subunits, which are defined by landforms, land loss rates and habitat types. The 104 ecologic planning subunits are located in the coastal zone. The 81 hydrologic/economic planning subunits are located wherever structures are at risk of flooding in the study area both within and outside of the coastal zone. (This is relevant because projects in the coastal zone are subject to consistency with the Louisiana Coastal Zone Management Program.)

3.0 **Non-Federal Sponsor**

A Feasibility Cost Share Agreement with the Coastal Protection and Restoration Authority of Louisiana, now known as the Coastal Protection and Restoration Authority Board of Louisiana (CPRAB), was executed for this study on January 14, 2009. CPRAB will be the non-Federal sponsor for implementation.

4.0 Problems/Opportunities

Problem Statement: The people, economy, unique environment and cultural heritage of southwest Louisiana are at risk due to storm surge flooding and wave impacts from tropical storms. The area's low elevation, proximity to the Gulf of Mexico, land subsidence, and rising sea level, are expected to exacerbate coastal flooding, shoreline erosion, saltwater intrusion, and loss of wetland and chenier habitats in the future.

System-wide problems and opportunities were used to identify and define more geographically specific problems and opportunities. Problems include the following:

- Flooding from tidal surge and waves associated with tropical storms.
- Increased flood durations in wetlands, resulting in wetland loss.
- Erosion of channel banks and shorelines, resulting in wetland loss.
- Deforestation and mining of chenier ridges.

Opportunities to solve the problems include:

- Incorporate structural and nonstructural coastal storm damage reduction solutions to reduce the risk of damages and prevent loss of community cohesion.
- Improve internal system hydrology to restore wetlands.
- Manage salinity levels to maintain fresh and intermediate marsh.
- Reduce bank and shoreline erosion.
- Prevent loss of significant historic and cultural resources.

5.0 Planning Goals/Objectives

The planning goals are to reduce storm surge flooding and coastal storm damages to provide sustainable ecosystem restoration. Specific planning objectives have been identified to solve the problems by taking advantage of opportunities.

- Objective 1. Reduce the risk of damages and losses from hurricane and storm surge flooding.
 - ▶ Metric: reduction in annual damage costs.
 - ▶ Data required: average annual expenditures on repairs due to storms and storm surges.
 - ▶ Data collection: inputs for HEC-FDA, HEC-RAS, state master plan, and ADCIRC.
- Objective 2. Manage tidal flows to improve drainage and prevent salinity from exceeding 2 ppt for fresh marsh and 6 ppt for intermediate marsh.
 - ▶ Metric: salinity in major watersheds (Cameron-Creole Watershed and Mermentau Basin) reduced to less than 2 ppt for fresh marsh and less than 6 ppt for intermediate marsh during the growing season of March to September; accretion, subsidence, water levels.
 - ▶ Data required: salinity measurements, accretion and subsidence rates; marsh elevation.
 - ▶ Data collection: Coastwide Reference Monitoring System (CRMS) or other stations.
- Objective 3. Increase wetland productivity in fresh and intermediate marshes to maintain function by reducing the time water levels exceed marsh surfaces.
 - ▶ Metric: flooding reduced to less than 60% of the time between March and September for non-flotant marshes; length of time the water surface elevation is above marsh surface.
 - ▶ Data required: depth, duration, and frequency of water and marsh surface elevations.
 - ▶ Data collection: CRMS or other monitoring stations.
- Objective 4. Reduce shoreline erosion and stabilize canal banks to protect adjacent wetlands.
 - ▶ Metric: erosion rates for canal banks, shorelines, the GIWW, and the Gulf of Mexico.
 - ▶ Data required: shoreline position.

- ▶ Data collection: aerial photos (e.g., Digital Ortho Quarter Quadrangle), LIDAR survey, and bathymetric/topographic surveys.
- **Objective 5.** Restore landscapes, including marsh, shoreline, and cheniers to maintain their function as wildlife habitat and improve their ability to serve as protective barriers.
 - ▶ Metric: subaerial marsh and shoreline acreage; chenier tree canopy and understory coverage increased up to 50% in restored tracts.
 - ▶ Data required: marsh/water acres; tree canopy and understory coverage.
 - ▶ Data collection: aerial imagery (e.g., Digital Ortho Quarter Quadrangle), LIDAR survey, bathymetric/topographic surveys, and forest vegetation surveys.

6.0 Planning Constraints

Plans will be restricted by the following constraints that are to be avoided or minimized.

- Commercial navigation.
The Calcasieu and Sabine Ship Channels and the GIWW carry significant commercial navigation traffic. Measures that would cause shipping delays would result in negative NED impacts. In addition, the ability of authorized navigation projects to fulfill their purpose, such as locks along the GIWW, may be affected by project features.
- Federally threatened and endangered species (i.e., piping plover) and their critical habitats.
Construction windows of the following species that are resident in the area overlap and/or may include the entire year: Piping Plover, Gulf Sturgeon, Red-Cockaded Woodpecker, Red Knot, Whooping Crane, West Indian Manatee, and several species of sea turtles.
- Essential fish habitat, especially intertidal wetlands.
Conversion of one EFH type to another should be done without adversely impacting various fish species. For example, conversion of shallow open water EFH to marsh EFH.
- Historic and cultural resources.
Ninety-nine archeological sites have been identified within a one-mile buffer of NED and NER alternatives, including one historic site (“Arcade Theater”) listed on the National Register of Historic Places (NRHP) and six potentially eligible prehistoric sites. Twelve historic properties listed on the NRHP have been identified within the one-mile buffer, including the Charpentier (Lake Charles) Historic District, as well as four eligible standing structures. Hundreds of standing structures in the area have a minimum age of 50 years and have not been assessed for eligibility.

7.0 Formulating Alternative Plans

This section describes how alternative plans were formulated for NED and NER purposes. Some common details for both the NED and NER purposes are provided upfront in this section and then each purpose is separately described.

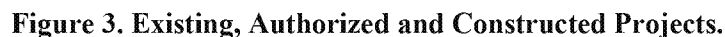
NED - Coastal Storm Damage Reduction Formulation

One plan to address coastal storm damages, a 12-foot levee along the GIWW, was identified in the Congressional NED authorization. In addition, previous studies and plans provide insight into area problems and offer potential solutions for evaluation in this study.

NER – Coastal Ecosystem Restoration Formulation

Coastal erosion in the Chenier Plain accounts for approximately 20 percent of the land loss in Louisiana. The Chief’s Report for the LCA Near-Term Plan discussed reducing wetlands losses by 50 percent. A

Nine sources were used to identify potential measures for both NED and NER evaluations:



- Louisiana State Master Plan
- Louisiana Coastal Protection and Restoration Technical Report (Plan Formulation Atlas)
- Louisiana Coastal Area “Plan That Best Meets the Objectives”
- Multiple Lines of Defense Strategy Report
- Coastal Wetlands Planning, Protection and Restoration Act Program
- National Environmental Policy Act (NEPA) Scoping Meetings
- Vermilion Parish Hurricane Protection Plan
- Cameron Parish Coastal Zone Management Plan
- Southwest Coastal Study Project Delivery Team.

1. Coastal storm damage reduction measures. These include structural and nonstructural features, programs, and activities.
2. Hydrologic and salinity control measures. These would improve wetlands hydrology.
3. Bank/shoreline stabilization measures. These would reduce erosion of canal banks and shorelines in critical areas to protect adjacent wetlands.
4. Preservation/restoration of unique natural features. This grouping included restoration of chenier ridges, as well as measures to restore and maintain oyster reefs. Cheniers provide geomorphic

structure, and function as wildlife habitat, while oyster reefs help prevent marsh erosion, baffle water currents, regenerate nutrients, and feed terrestrial and aquatic predators.

5. Marsh creation measures. The measures would create or restore marsh, which would contribute to marsh function as wildlife habitat, as well as provide storm surge buffers.
6. Miscellaneous measures. These ranged from watershed sediment and water level management measures to measures that would affect waterways, such as navigability.

Plan formulation was broken into two parts for the NED and NER study components.

For purposes of presentation here the NED evaluation is conducted first all the way through identification of a draft TSP.

Second, the NER formulation, evaluation of plans and identification of the draft TSP is presented in its entirety after the NED section.

During development of feasibility level design for the plans some additional modeling and analysis will be conducted to determine combinability of the NED and NER plans. A final assessment of the contributions or interrelationship between the plans will be made prior to the Final Report milestone.

COASTAL STORM DAMAGE REDUCTION FORMULATION

Early effort modeling was performed to visually determine where the storm risk potential exists in the study area (see Figure 4). The red dots are structures within the inventory that are at risk of flood damages. At risk structures are concentrated in several areas. In these locations levee systems can be proposed to efficiently reduce risk. The remainder of the study area is less densely populated whereby the structures at risk are dispersed over large areas. Therefore, non-structural measures were considered more appropriate in those areas.

NED 7.1 Management Measures

Many features and measures were identified to address objective 1.

Structural Features:

- Earthen Levees.
- Floodgates.
- Floodwalls.
- Pumps.
- Highway armoring.

Nonstructural Measures:

- Structure Raising.
- Property Buyouts.
- Floodproofing Methods.
- Flood Plain Management Evacuation Plans.
- Public Information Campaigns.

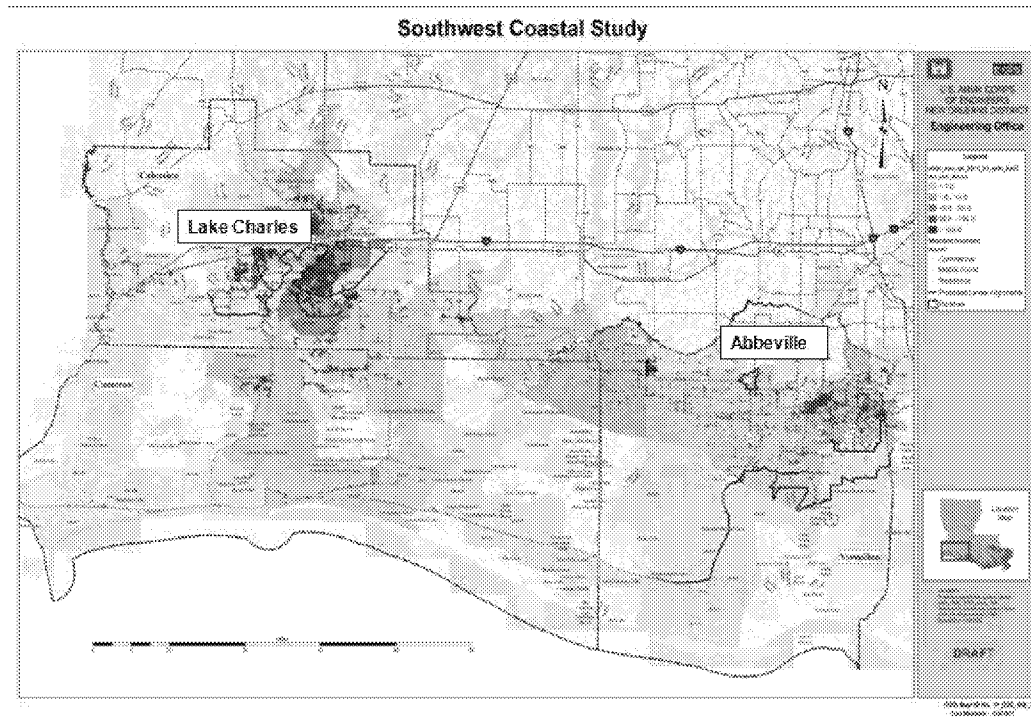


Figure 4. NED Early Modeling Results.

The following 14 coastal storm reduction measures were identified for further analysis.

Armored 12 Foot Levee along the GIWW.

Lake Charles levee variations:

- Lake Charles (Measure 149) - southern (east and west).
- Lake Charles (Measure 149) - southern/eastern only.
- Lake Charles (Measure 149) - southern/western only.
- Lake Charles (Measure 411/412) - northern (east and west).
- Lake Charles (Measure 411/412) - northern/east only.
- Lake Charles (Measure 411/412) - northern/west only.

Abbeville levee variations:

- Abbeville Marsh/Upland Interface (Measure 144).
- Abbeville along GIWW (from Reconnaissance Study).
- Abbeville along LA Hwy 330 (Measure 114b).
- Abbeville (shortened variation) – Excludes Erath and Delcambre.

Gueydan levee (Measure 146).

Kaplan levee (Measure 409).

Louisiana Highway 333/82 armoring.

NED 7.2 Screening of NED Measures

The NED screening process followed the steps below:

- An inventory of 52,000 residential and non-residential structures within the southwest coastal flood zone provided replacement values and first floor elevations.
- Industrial structures were not considered in the initial screening.
- Hydrologic reaches were defined resulting in 81 reaches.
- A range of low and high costs were developed for measures and features.
- Damage estimates were developed and multiplied by a rule of thumb based on the reciprocal of interest and amortization (in this case 20) to determine the level of construction costs that could be supported. Stage-probability curves blend HEC-RAS (for rainfall) and ADCIRC (surge) model results. They represent 2012 existing conditions.
- The supportable costs were used as a surrogate for benefits. The difference between benefits and cost (for high and low) were assumed to represent net benefits.
- Simplifying assumptions were made:
 - ▶ No induced damages from flooding outside levees. No damages from waves.
 - ▶ No future development or emergency costs.
 - ▶ No surge or rainfall damages for events between 25 and 200 years. Net benefits less than zero were used to screen alignments.
 - ▶ Intermediate Relative Sea Level Rise was used for future conditions.

Measure Name (Measure ID)	Levee Length (miles)	Best Estimate Benefits x 20 in mil \$	"Low Cost Scenario" Levee + Pumps in mil \$	"High Cost Scenario" Levee + Pumps in mil \$	Are best estimate benefits x 20 greater than "Low" costs?	Are best estimate benefits x 20 greater than "High" costs?	Screening Decision
Armored 12-ft Levee along the GIWW (per study authority and Recon Alt S-1)	122	1,835.5	2,562.0	3,904.0	No	No	Screen out; not enough benefits (once repetitive damages removed) to justify structural solution cost
Gueydan Levee (146)	6	8.1	114.0	174.0	No	No	Screen out; damages would have to increase by orders of magnitude to justify structural solution cost
Abbeville Levee along Hwy 330 (114b)	13	336.1	247	377	Yes	No	Although benefits are less than high cost estimates, they are within a margin of error. Consider further for reformulation.

Table 1. Example of NED Screening.

The screening removed all plans with net benefits less than zero. The screening process is demonstrated with three of the measures under consideration in Table 1.

Plan Development Strategies. After initial screening, 18 storm damage reduction alternatives remained.

Structural and nonstructural measures were combined to form comprehensive risk reduction plans for the entire study area. North of the GIWW, combinations of structural and nonstructural measures were based on existing plans (Southwest Coastal Recon Study, LACPR, State Master Plan, and Vermilion Parish Plan). South of the GIWW, structural plans were not economically justified because of the smaller, dispersed (rural) populations. Out of approximately 52,000 structures in the study area, only about 5-6% of them are located south of the GIWW. The resulting three alternative plans in the initial array are:

- Armored 12-foot Levee along the GIWW (Recon Alternative S-1). Study authority requires assessing the “feasibility of constructing an armored 12-foot levee along the Gulf Intracoastal Waterway.” This 122-mile levee was determined to be marginally justified in the 2007 Reconnaissance Report, but is not in the 2012 State Master Plan. Nonstructural measures would be applied to communities south of the GIWW, including Cameron, Hackberry, Holly Beach, Creole, Grand Cheniere, Pecan Island, and

Intracoastal City. [NOTE: Although this plan was screened earlier the team carried it one step further to gain certainty in the assessment. This helped address the requirement in the study authority.]

- Comprehensive levee plan. As an alternative to a long, continuous levee along the GIWW, individual levees would be built around the largest population centers and nonstructural measures would be applied in all other areas. Levees are included around the Lake Charles area, Abbeville area (including Erath and Delcambre), Kaplan, and Gueydan. The Lake Charles metropolitan area is the largest urban center in the study area, with a population of approximately 194,000 according to a 2009 census estimate. From west to east, the communities of Gueydan, Kaplan, Abbeville, Erath, and Delcambre are located in northern Vermilion Parish along Hwy 14 and have populations of around 1,600, 5,200, 12,300, 2,200, and 2,200 respectively in the 2010 census. The 2012 State Master Plan includes levees in both the greater Lake Charles and Abbeville areas. The Kaplan and Gueydan levees were included in the LACPR alternatives.
- Comprehensive nonstructural plan. As an alternative to structural solutions, nonstructural measures would be applied to the entire study area. Nonstructural measures and activities were proposed to address individual reaches. In this manner, households and businesses would be provided storm damage risk reduction through a variety of nonstructural avenues, including structure elevating, buy-outs, and programs, such as evacuation plans.

Industrial structures were removed due to their small number and their disproportionately high economic value. They will be considered individually in future analyses. Commercial structures were assigned residential values for this screening.

NED 7.3 Key Uncertainties

Key uncertainties identified in the NED risk register involve the following areas.

- Relative sea level rise and subsidence rates. If sea level rise and subsidence estimates are not accurate, the performance will be different.
- Frequency and intensity of storms. Underestimates will result in additional storm damages.

NED 7.4. Focused Array of Alternative Plans

- The armored 12 foot levee along the GIWW was not carried into the focused array because potential benefits do not justify estimated costs.
- Benefits for the east Lake Charles levees outweigh costs, but for the western Lake Charles levees, costs outweigh benefits. Together the east and west levees did not have enough benefits to justify cost, but since the difference in costs and benefits was within the margin of error, and since a 500-year structural solution for Lake Charles is included in State Master Plan, the Lake Charles levee was carried forward into the focused array.
- Most of the Abbeville levee variations had higher costs than benefits; however, since at least one of the variations showed the potential for benefits higher than costs; the benefits and costs were within the margin of error; and a structural solution for Abbeville is included in the State Master Plan, the Abbeville levee was carried forward into the focused array.
- Since both the Kaplan and Gueydan benefits were an order of magnitude less than the costs, those levees were removed from the comprehensive levee plan and replaced with nonstructural measures.

Based on the screening conclusions, the focused array of NED alternatives includes the following eight plans and a no action plan. Figures 5, 6, and 7 show the locations of the proposed alignments with respect to Lake Charles, Abbeville, Delcambre, and Erath.

No Action Plan – Future without-project condition.

- 1. Lake Charles Eastbank.
- 2. Lake Charles Westbank Sulphur Extended.
- 3. Lake Charles Westbank Sulphur South.
- 4. Abbeville to Delcambre Hwy 330.
- 5. Delcambre/Erath.
- 6. Abbeville.
- 7. Abbeville to Delcambre.
- 8. Nonstructural Plan.

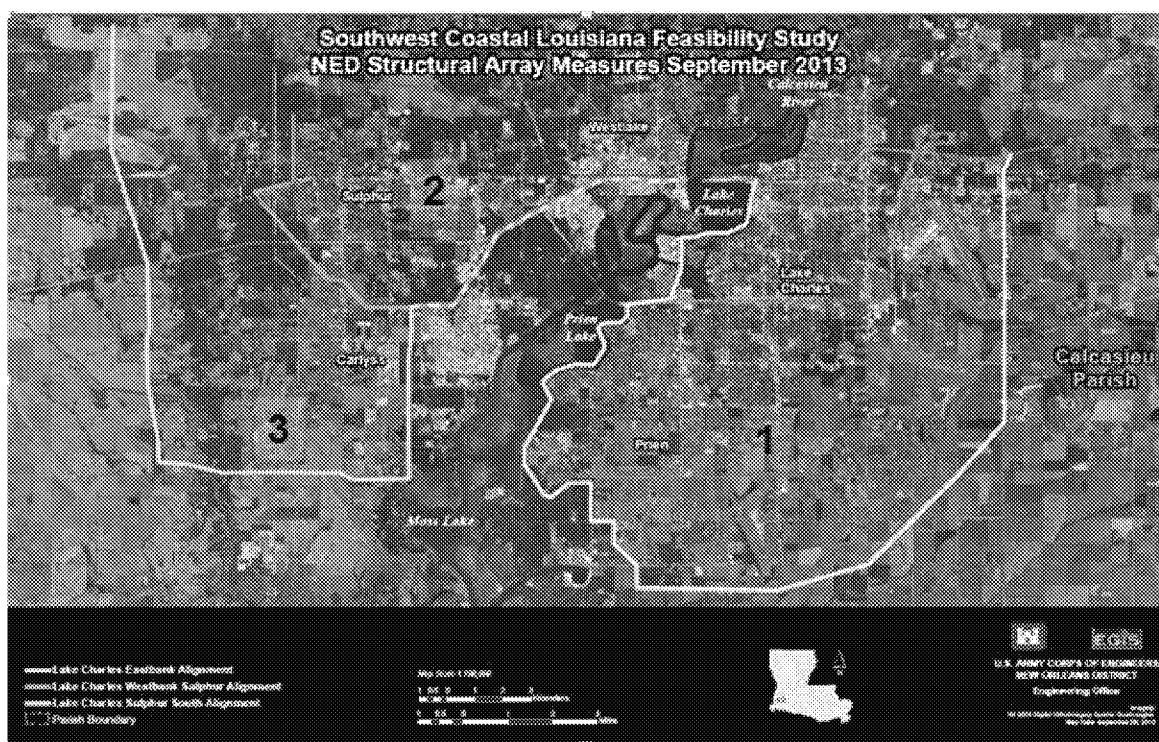


Figure 5 Lake Charles.

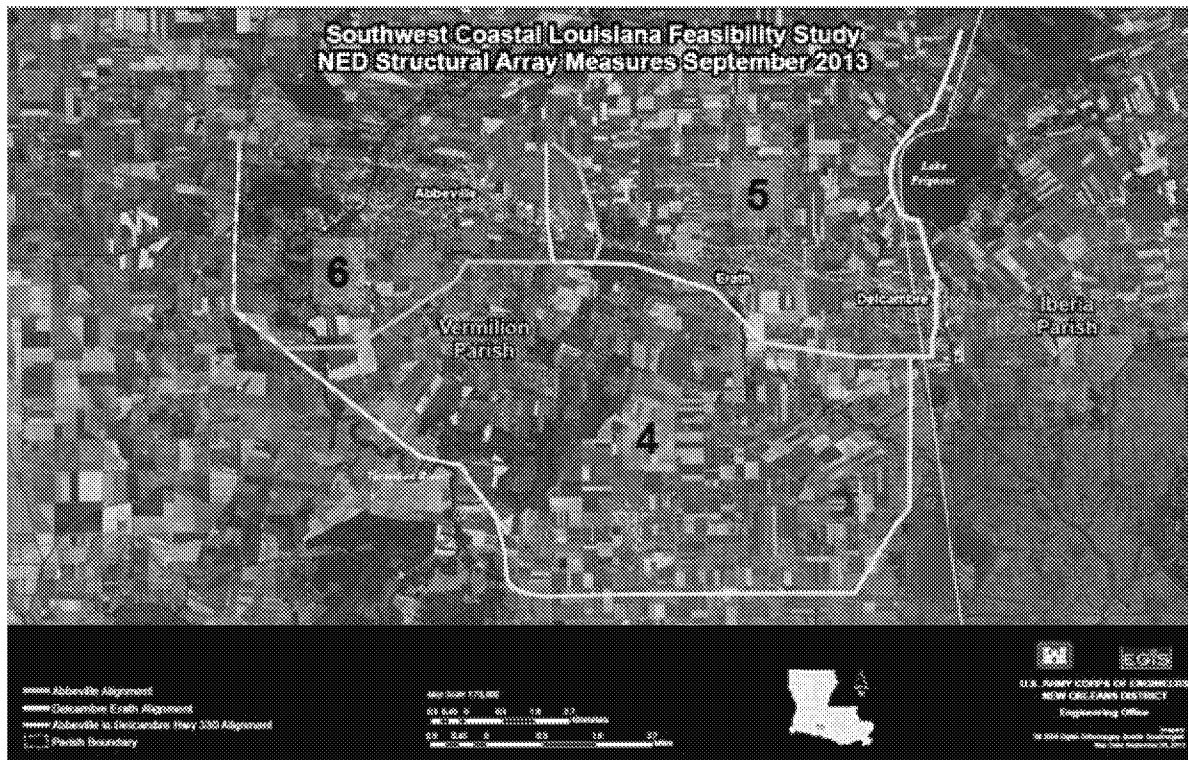


Figure 6. Abbeville, Delcambre, and Erath.



Figure 7. Abbeville to Delcambre Combined.

NED 8.0 Evaluation of Focused Array of Alternative Plans

Structural Evaluation.

Utilizing existing data, current and future without-project damages, and parametric costs, with project damages were developed for base and future conditions. The alternatives were screened based on the 0.02 percent, 0.01 percent and 0.005 percent (50 year, 100 year, and 200 year) levels of risk reduction.

Using the damage probability relationship from the HEC-FDA model for the damage reaches receiving risk reduction from each of the six project alternatives, it was estimated that a 0.02 percent (50 year) project would eliminate damages for the 25 and 50 year events. The 0.01 percent (100 year) project would eliminate damages for the 25, 50 and 100 year events and the 0.005 percent (200 year) project would eliminate damages for the 25, 50, 100 and 200 year events. The six alternatives would not eliminate damages from rainfall at the more frequent events (1 and 10 year events).

A percentage was applied to the overall benefits by reach for each of the six alternatives to reflect the estimated percentage of the total structures in a reach that are receiving risk reduction from each alternative. For example, approximately 40 percent of the residential and non-residential structures in reach XA-305 lie behind the proposed levee alignment. Therefore, the estimated total benefits calculated for that reach are multiplied by 40 percent to determine the benefits for the Abbeville to Delcambre alternative for reach XA-305. This methodology was applied to all proposed alternatives.



Figure 8. Justified Nonstructural Reaches.

Nonstructural Evaluation

- Any structure with first floor elevation below the elevation of the 100-year storm event was considered for participation in a Nonstructural Plan.
- Three actions were considered. Residential structures could be elevated or acquired. Structures would be elevated up to a maximum 13 feet. Structures that require raising over 13 feet would be identified for acquisition to remove them from the 100 year flood plain. Nonresidential structures would be flood proofed up to three feet above the existing first floor elevation.
- Costs of measures at the reach level were estimated and compared to damages reduced.

- Justification was determined by comparing expected annual benefits to expected annual costs. Net benefits were calculated by subtracting expected annual costs from expected annual benefits.
- The analysis found 11 of 81 reaches were economically justified as shown in Figure 8 above.
- Figure 9 identifies costs, benefits, and benefit cost ratios for each of the justified reaches.

Reach	Total Cost (in Th \$)	Number of Structures in Reach	Average Annual Cost (in Th \$)	Equivalent Annual Benefits (in Th \$)	Benefit Cost Ratio	Net Benefits (in Th \$)
SA-033- RL(76)	8,466	77	361	369	1.01	3
SA-034(79)	9,591	122	409	622	1.51	208
SA-048(106)	34,647	389	1,477	2,022	1.36	532
SA-070- S(139)	13,687	134	583	934	1.59	345
SA-091(187)	12,896	169	550	1,362	2.46	802
SA-112(250)	10,177	148	434	573	1.31	132
XA- 306(280)	296,306	2,860	12,632	14,691	1.15	1,958
XA- 324(337)	1,232	7	53	66	1.26	13
XA- 327(346)	114	1	5	8	1.66	3
XA- 336(373)	583	5	25	131	5.22	105
XA- 341(388)	341	3	15	36	2.44	21

Figure 9. Nonstructural Results by Justified Reach.

NED 9.0 Comparison of Focused Arrays of Alternative Plans / Decision Criteria

Comparison of NED structural alternatives used traditional cost benefit analysis. Expected annual estimated benefits for 2025 and 2075 were converted to an equivalent annual value using the current interest rate, 3.5 percent, and a 50-year period of analysis. Total cost and estimated annual costs for the project alternatives included the construction costs and operation and maintenance for three levels of risk reduction. Construction costs, along with the schedule of expenditures, were used to determine the interest during construction and gross investment cost at the end of the installation period. Each of the project alternatives is scheduled to begin construction in the year 2017 and will continue through the year 2024 with additional levee lifts beginning in 2067 and construction ending six to seven years later. The first levee lifts will be overbuilt and allowed to settle for several years before the latter levee lift is added for each alternative. Later levee lift will account for the relative sea level rise and subsidence that is projected to occur throughout the period of analysis.

Tables 2 through 4 show the focused array results for first construction costs; average annual costs, average annual benefits; benefit/cost ratios; and net benefits for each alternative analyzed in the focused array. As indicated by the red font, the Lake Charles Eastbank was the only alternative with a justified benefit cost ratio. Lake Charles Eastbank was justified at each level of protection. The highest net benefits were for the Lake Charles Eastbank plan at the 200 year level of protection.

Alternatives	First Costs (in Mil \$)	Average Annual Costs (in Mil \$)	Average Annual Benefits (in Mil \$)	Benefit/ Cost Ratio	Net Benefits (in Mil \$)
Abbeville to Delcambre	628.5	27.8	19.4	0.70	-8.4
Delcambre/Erath	359.4	15.5	11.1	0.72	-4.4
Abbeville	286.0	12.9	2.6	0.20	-10.3
Lake Charles Westbank Sulphur Extended	142.8	6.5	1.4	0.22	-5.0
Lake Charles Westbank Sulphur South	456.3	20.7	3.0	0.14	-17.7
Lake Charles Eastbank	779.4	35.8	37.6	1.05	1.9

Table 2. Fifty Year Level of Risk Reduction.

Alternatives	First Costs (Mil \$)	Average Annual Costs (Mil \$)	Average Annual Benefits (Mil \$)	Benefit/ Cost Ratio	Net Benefits (Mil \$)
Abbeville to Delcambre	784.2	34.4	27.1	0.79	-7.3
Delcambre/Erath	470.8	20.3	14.5	0.72	-5.8
Abbeville	344.1	15.4	7.2	0.47	-8.2
Lake Charles Westbank Sulphur Extended	199.3	8.6	3.3	0.39	-5.2
Lake Charles Westbank Sulphur South	629.1	27.6	7.2	0.26	-20.4
Lake Charles Eastbank	979.1	43.9	50.7	1.16	6.8

Table 3. One Hundred Year Level of Risk Reduction.

Alternatives	First Costs (Mil \$)	Average Annual Costs (Mil \$)	Average Annual Benefits (Mil \$)	Benefit/Cost Ratio	Net Benefits (Mil \$)
Abbeville to Delcambre	1000	43.6	32.5	0.75	-11.1
Delcambre/Erath	589.5	25.4	17	0.67	-8.5
Abbeville	447.7	19.9	9.7	0.49	-10.2
Lake Charles Westbank Sulphur Extended	327.1	13.9	5.5	0.39	-8.4
Lake Charles Westbank Sulphur South	883.9	38	12.5	0.33	-25.5
Lake Charles Eastbank	1224.1	54.2	61.1	1.13	6.9

Table 4. Two Hundred Year Level of Risk Reduction.Nonstructural Plan Analysis.

Cost benefit analysis of nonstructural alternatives was performed at the reach level. Economic justification of reaches was determined by a comparison of average annual benefits to average annual costs. Reaches with benefit/cost ratio greater than one were selected for the nonstructural plan. All justified reaches are included in the plan. See Table 5 for a summary of the net benefits of the structural alternatives combined with the Nonstructural Plan benefits. The nonstructural plan benefits of \$4.3 million are shown with a star, and they line up with the 100 year level of protection. The plan considered any structure with a first floor elevation (FFE) below the 100 year stage. This was done to correspond with FEMA regulations that require new development to FFE higher than the 100 year flood plain.

Alternatives	50 year (Mil \$)	100 year (Mil \$)	200 year (Mil \$)
Abbeville to Delcambre	-8.4	-7.3	-11.1
Delcambre/Erath	-4.4	-5.8	-8.5
Abbeville	-10.3	-8.2	-10.2
Lake Charles Westbank Sulphur Extended	-5.0	-5.2	-8.4
Lake Charles Westbank Sulphur South	-17.7	-20.4	-25.5
Lake Charles Eastbank	1.9	6.8	6.9
Nonstructural Plan		4.3*	

Table 5. NED Net Benefits.

NED 10.0 Identifying a Tentatively Selected Plan

Description of the Draft Tentatively Selected Plan.

- Eleven nonstructural reaches
 - ▶ Includes 11,272 total structures in 2025.
 - ▶ Includes 15,332 total structures in 2075.
- Structural alignment for Plan 1. Lake Charles East Bank, 200 year protection.
 - ▶ 34 miles of earthen levee.
 - ▶ Pumping capacity of 3,000 cubic feet per second.
 - ▶ Sector gate, 2 stop log gates and 2 drainage structures.
- Preliminary Estimated Cost: \$1.6 Billion

Figure 9 shows the draft NED TSP, including the nonstructural reaches and the structural alignment.

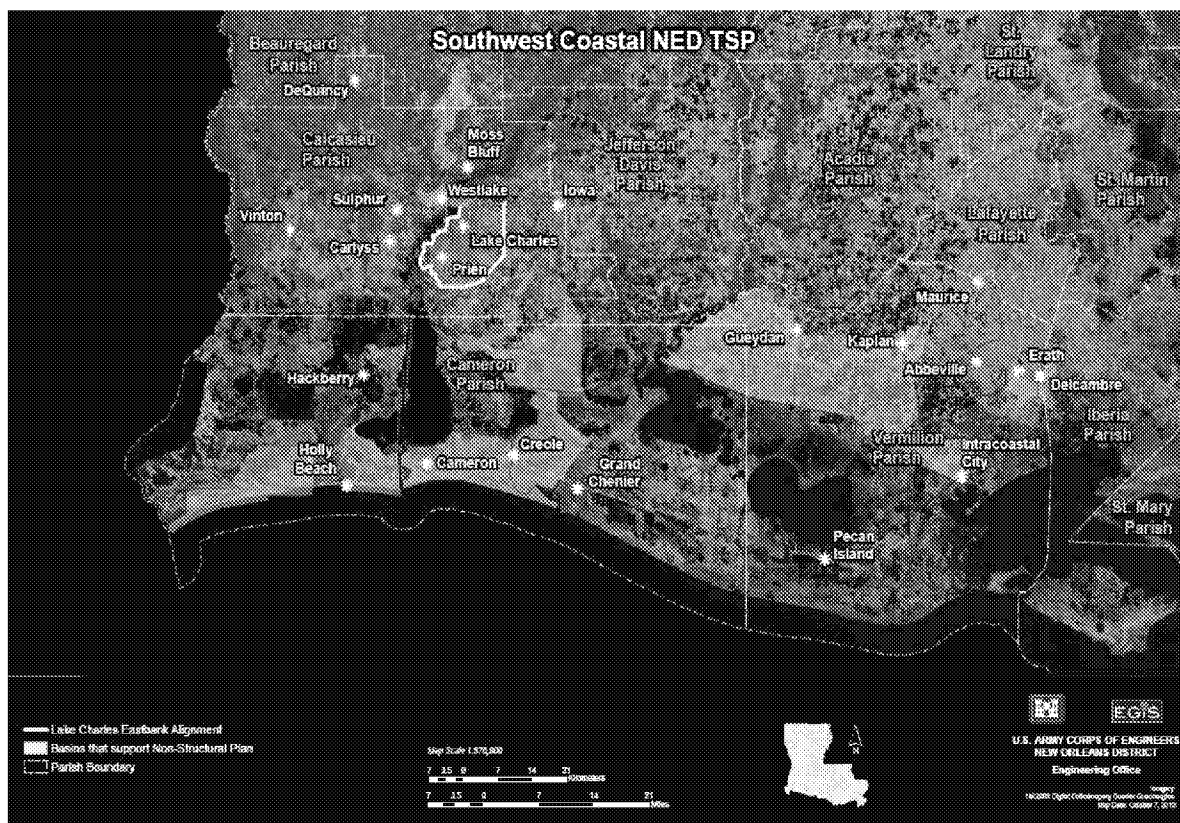
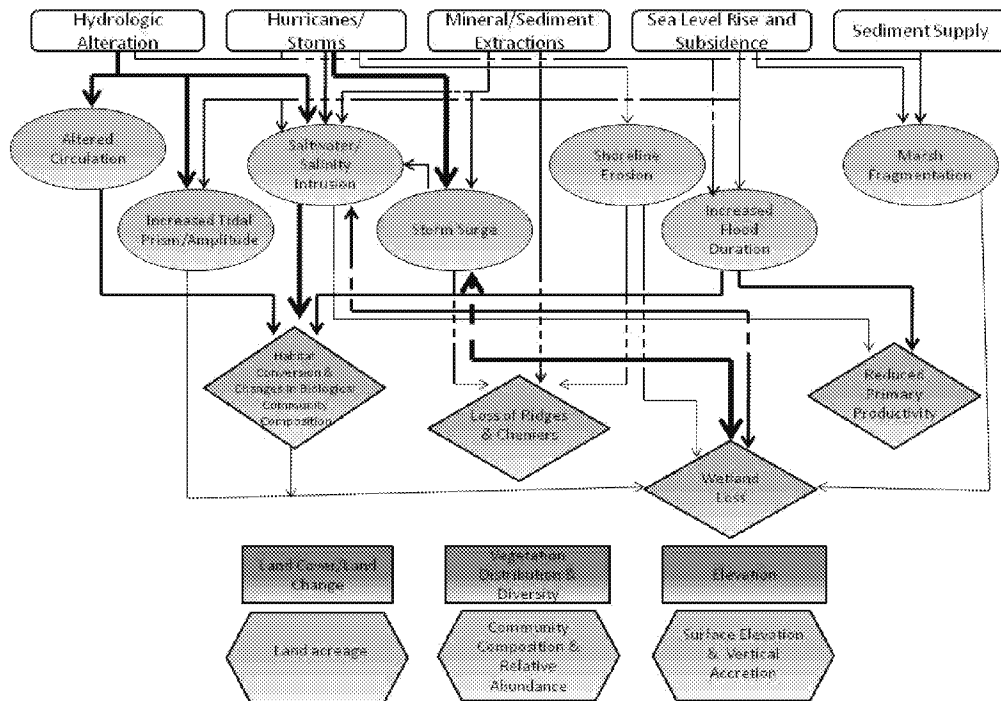


Figure 9. NED TSP.

ECOSYSTEM RESTORATION FORMULATION



A conceptual ecosystem model was developed in conjunction with ERDC. It identified five drivers, six ecological stressors, and four ecological effects. The most serious problem was identified as the rate of land and habitat loss.

NER 7.1 Management Measures

The State Master Plan (2012) and the LACPR Report (2009) were key sources of measures.

- Marsh restoration measures are needed to restore critical geomorphologic features and improve hydrology of wetlands, as well as provide storm surge buffers.
- Bank and shoreline stabilization measures are intended to reduce erosion of canal banks and shorelines in critical areas; they support system structure.
- Hydrologic and salinity control measures are crucial to reduce flooding and minimize saltwater intrusion in marshes.
- Chenier reforestation measures support wildlife and system structure.
- Oyster reef restoration measures improve the hydrology of wetlands.

NER 7.2 Screening of Measures

Initial data collection included numerous sources of NER measures and concepts. Most were in-basin and/or location specific, but some applied to the overall study area. Over 200,000 acres of marsh restoration and about 360 miles of bank and shoreline were identified in scoping efforts. Measures were categorized by basins.

Calcasieu-Sabine Basin

Hydrologic and salinity control measures at channel entrances and in critical locations around the basin perimeter; shore protection and marsh restoration measures; Sabine oyster reef protection; and chenier reforestation between the GIWW and Gulf, primarily in the Calcasieu Lake vicinity.

Mermentau and Teche-Vermilion Basins

Hydrologic and salinity control measures in critical locations; shoreline protection and marsh restoration measures; West Cote Blanche Bay and Vermilion Bay oyster reef restoration; and chenier reforestation between the GIWW and Gulf, primarily south of Grand and White Lakes and in the vicinity of Freshwater Bayou.

Preliminary costs and benefits for marsh creation and shoreline protection measures were estimated. Screening was performed using the following criteria.

Support for goals and avoidance of constraints. An example of this screening category was the elimination of measures that were not expected to be sustainable. Thus, marsh creation measures located in areas with open water areas where depth is greater than 2 feet or in high subsidence areas were screened, along with chenier reforestation in locations with elevations less than 5 feet and areas with high shoreline erosion rates.

Support for objectives. These criteria served as verification of previous screenings, to ensure that the measures being considered for inclusion were applicable to Southwest Coastal objectives. Each of the measures was found to support the relevant objective. Marsh creation measures that support Objective 5, to restore critical geomorphologic features to maintain their function as wildlife habitat and as protective barriers, were retained. An example is the screening of marsh creation measures south of Highway 82 (47a-h) because they were not supportive of any critical landscape features. Shorelines experiencing high recession rates in areas adjacent to wetlands, such as measures providing protection for the Rockefeller Wildlife Refuge (6b1-6b3) were carried forward, in compliance with Objective 4, to reduce shoreline erosion and stabilize canal banks in southwest coastal Louisiana areas to protect adjacent wetlands.

Effectiveness. There were different thresholds used to identify whether measures were considered to be effective. Hydrologic and salinity controls were screened if they did not produce benefits for at least 500 net acres. Marsh creation measures needed to create at least 100 acres. Oyster reef measures were all considered to be effective measures.

Efficiency. The final criteria compared cost per acre within the measure categories. An example is the screening of West Cove marsh creation measures (49a1 and 49a2), since another marsh creation measure, Mud Lake (124d), would provide protection at a cheaper cost.

Table 6 summarizes the screening criteria and decisions.

Screening Criteria		Table 6. Application of NER Screening Criteria.				
		Marsh Restoration	Bank/Shoreline Stabilization	Chenier Reforestation	Hydraulic & Salinity Control	Oyster Reef Restoration
Constraints and Goals	Measure does not meet goal or it violates a planning constraints.	Screened non-sustainable measures, e.g., open water areas where depth is > 2 feet, high subsidence areas.	None of the shoreline measures were screened out.	Non sustainable chenier reforestation measures were screened out. This applied to elevations < 5 feet and areas with high shoreline erosion rates.	No hydraulic or salinity control measures were screened out.	None of these measures were screened out.
Objectives	Measure does not address one or more of the study planning objectives.	All marsh measures met Objective 5, to restore critical geomorphologic features to maintain their function as wildlife habitat and as protective barriers.	All shoreline measures met Objective 4, to reduce erosion of canal banks and shorelines in critical areas to protect adjacent wetlands.	All chenier reforestation measures meet Objective 5, to restore critical geomorphologic features to maintain their function as wildlife habitat and as protective barriers.	All hydraulic and salinity control measures met Objective 2, preventing excess salinity and/or Objective 3, to increase wetland productivity to maintain function.	All measures met Objective 5, to restore critical geomorphologic features to maintain their function as wildlife habitat and as protective barriers.
Effectiveness	Measure found to be ineffective.	Marsh or shoreline measures producing or protecting less than 100 net acres were considered to be ineffective and were screened unless they were critical components of the system.		Measures were screened out where existing canopy coverage deemed substantially intact (i.e. >50%) or if the presence of development would prohibit reforestation.	A small number of hydraulic and salinity control measures were screened as ineffective because they did not produce hydrologic benefits of at least 500 net acres.	None of the oyster reef restoration measures were screened out since it is deemed to be an effective method of using a natural feature to limit saltwater intrusion.
Efficiency	Measure found to have below average efficiency.	The average cost of all marsh and shoreline measures based on the initial evaluation was approximately \$125,000/net acre. Measures with greater than average cost/net acre were screened for inefficiency unless they were considered critical components of the system or if they were adjacent to significant resources, such as cheniers, and wildlife refuges		Not used for screening because all chenier measures were relatively efficient compared to each other.	Not used for screening because all hydraulic and salinity control measures were relatively efficient compared to each other.	None of the oyster reef restoration measures were screened out since they are considered to be an efficient method of providing ecosystem restoration benefits.

NER Screening Results

After the initial screening, 94 measures remained. The PDT determined that there were too many potential combinations of measures to use IWR Plan for CE/ICA analysis at this stage.

Alternatives based on individual measures and combinations of measure types (hydrologic and salinity control, marsh creation, shoreline protection, and chenier reforestation) were evaluated. The determination was made that no single measure type could achieve the study goals or objectives. At this point a series of strategies were developed to help aid in formulation.

NER Plan Development Strategies

The local sponsor offered comprehensive plans based on the State Master Plan. The 2012 Master Plan Models (i.e., the Wetland Morphology, Eco-Hydrology, and Vegetation models), provided a way to estimate the comprehensive benefits of salinity and water level control within the Southwest Coastal study area. Because the SW Coastal measures were already analyzed using these models as part of the 2012 Master Plan formulation, the results were used to screen the proposed H&S measures. The results of the State Master Plan Models were used to select those hydraulic and salinity control measures that showed the greatest benefits (i.e., regional effects resulting in greater than 500 net acres). The emphasis for marsh creation measures was on areas exposed to saltwater, tidal and wave action because of the critical need to introduce new sediment to these areas to increase wetland sustainability. Shoreline protection measures that protected cheniers and interior marshes were prioritized.

The PDT developed a focused array of 6 comprehensive alternative plans, incrementalized across the two major sub-basins, with and without major hydrologic and salinity control. Since the alternatives were scales of similar measures marsh creation, shoreline protection, and chenier reforestation measures generally performed in a linear fashion (greater investment producing corresponding output). As a result, these plans produced little useful incremental variation. Hydrologic and salinity measures did produce significant incremental variation, specifically a single measure, H&S #7, had potential, and was considered as a standalone alternative.

NER 7.3 Key Uncertainties

The key uncertainty identified in the NER risk register involves the following area.
Relative sea level rise. If RSLR is greater than expected, features may not function properly.

NER 7.4 NER Focused Array of Alternative Plans

The NER focused array alternatives in the Calcasieu-Sabine Basin are located between the GIWW and the Gulf of Mexico, primarily in the vicinity of Calcasieu Lake. Alternatives in the Mermentau/Teche-Vermilion Basins are primarily clustered south of Grand and White Lakes, and in the area surrounding Freshwater Bayou.

The focused array is shown below. Plans that were derived from the Louisiana State Master Plan are identified with SMP. For analysis purposes, each plan was divided into two geographic parts. C represents measures contained in the Calcasieu-Sabine Basin. M indicates measures that are located in the Mermentau/Teche-Vermilion Basins.

Plans 1, 2, 3, 4, and 7 contain H&S #7, indicated by either C#a or A.

- No Action Plan
- 1. Large Integrated Restoration Across Basins (C1a+M1) (SMP)
- 2. Moderate Integrated Restoration (Hydrologic Emphasis) (C2a+M2) (SMP)
- 3. Moderate Integrated Restoration, including Gum Cove (C3a+M3) (SMP)
- 4. Entry Salinity Control (C4a+M4) (SMP)

- 5. Interior Perimeter Control (C5+M5)
- 6. Marsh and Shoreline (Minimal Hydrologic & Salinity Control) (C6+M6)
- 7. Stand alone Entry Salinity Control Measure H&S #7 (A)

NER 8.0 Evaluation of Focused Array of Alternative Plans

NER plans in the focused array (excluding no action) address study objectives as follows:

- From a watershed perspective, all NER alternatives will contribute to Objective 1 by positively impacting the human and natural environments.
- All of the NER alternatives will meet Objective 2 by improving drainage and preventing excess salinity. They will either control salinity and flows at the main passes or where the high-salinity water would enter interior marshes.
- All of the NER alternatives will meet Objective 3, to increase wetland productivity, by reducing flooding in fresh and intermediate marshes during the vegetation growing season. They will increase the separation of the Grand and White Lakes from the Gulf of Mexico through construction of measure 127c3. Most of the ability to meet this objective is dependent on the operation of the existing structures to maintain target water levels. Measure 74a will increase control of drainage from the Cameron-Creole Watershed, and Measure 13 will increase control of drainage from the Mermentau Basin.
- All of the NER alternatives will address Objective 4, to reduce shoreline erosion and stabilize canal banks, in that they will protect critical shorelines. Alternative 1 and Alternative 6 will meet this objective the most; Alternatives 4 and 5 will meet this objective the least. Alternatives 2 and 3 will provide an intermediate level of protection for critical shorelines.
- All of the NER alternatives will meet Objective 5, to restore geomorphologic features to maintain their function as wildlife habitat and as protective barriers, in that all alternatives include marsh creation, oyster reef restoration and chenier reforestation.

NER 9.0 Comparison of Focused Array of Alternative Plans / Decision Criteria

The focused array of alternative plans were compared considering cost effectiveness and incremental cost analysis to inform environmental investment decision making. Cost effectiveness is expressed as: no other plan provides a higher output level of acres restored for the same or less cost. Incremental cost analysis is the determination of the greatest increase in output (acres restored) for the least increase in cost. Use of these tools helps decision makers determine the most desirable level of outputs (restored acres) compared to costs.

In the CE/ICA analysis shown in Figure 10, an average annual cost of \$10,000,000 was added to plans that contain Alternative A to represent a relatively high navigation cost resulting from the gate. The cost in this analysis represents traffic delays to all 2011 deep draft traffic in the Calcasieu Ship Channel. Comprehensive plans 1, 2, 3, and 4, as well as Calcasieu-Sabine plans, C1, C2, C3, and C4 were run with and without Alternative A to identify performance of the plans without it.

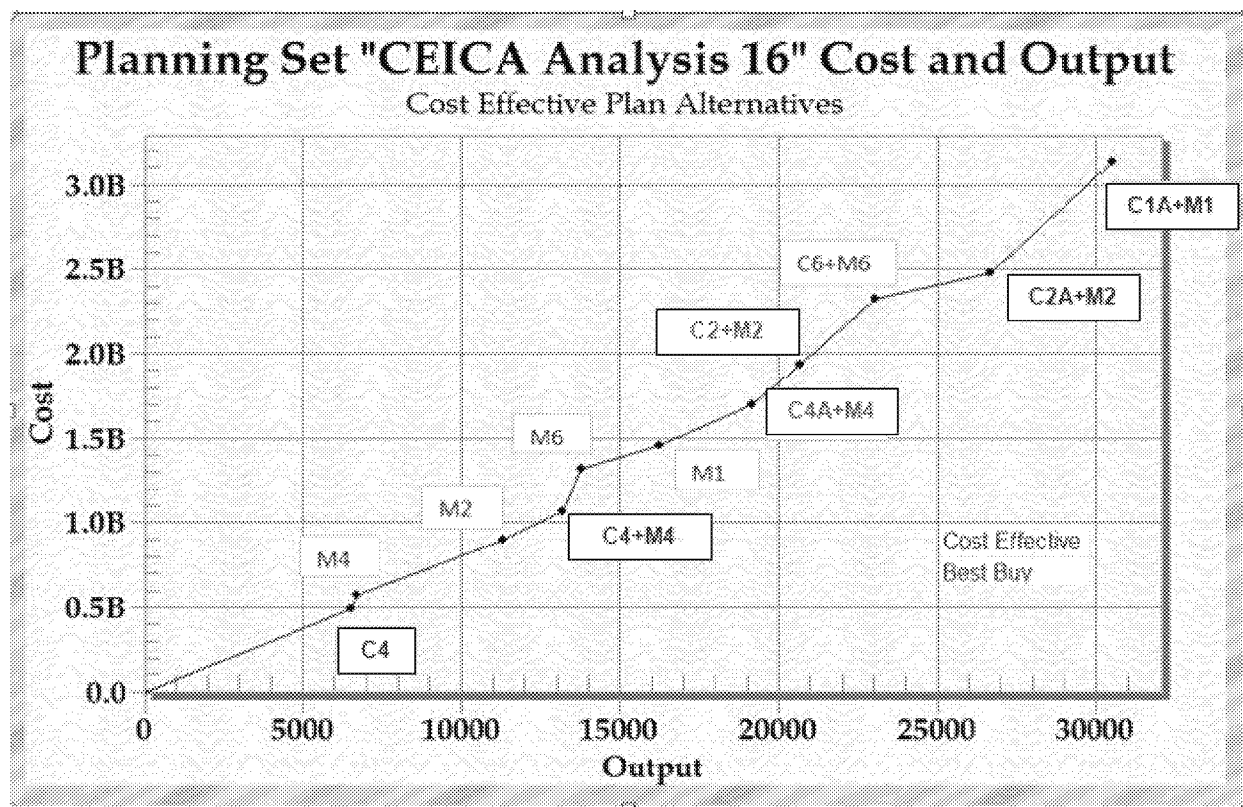


Figure 10. CE/ICA Analysis Using High Navigation Cost.

The second CE/ICA analysis is shown in Figure 11. It ran identical sets of plans, but used a lower average annual cost of \$7,672,500 to represent navigation delays caused by the gate for plans that contain Alternative A. The low cost accounts for delays to vessels that transited on the Calcasieu Ship Channel in 2011 with drafts between 15 and 35 feet. The purpose of using this lower cost estimate is to represent an operating scheme that would allow the gate to remain open during high tide, which is when the deepest draft vessels transit. Thus, a minimum representation of the impact of the gate closure is to add traffic delays for only non-deep draft vessels. The cost does not include tug assistance costs or any other ancillary impacts of a gate closure.

In both analyses, in order to be consistent with the cost provided for the measures, the average annual cost was converted to the present value of \$179,963,228. This present value cost was added to the cost of the plans that contain the gate (Alternatives 1-4).

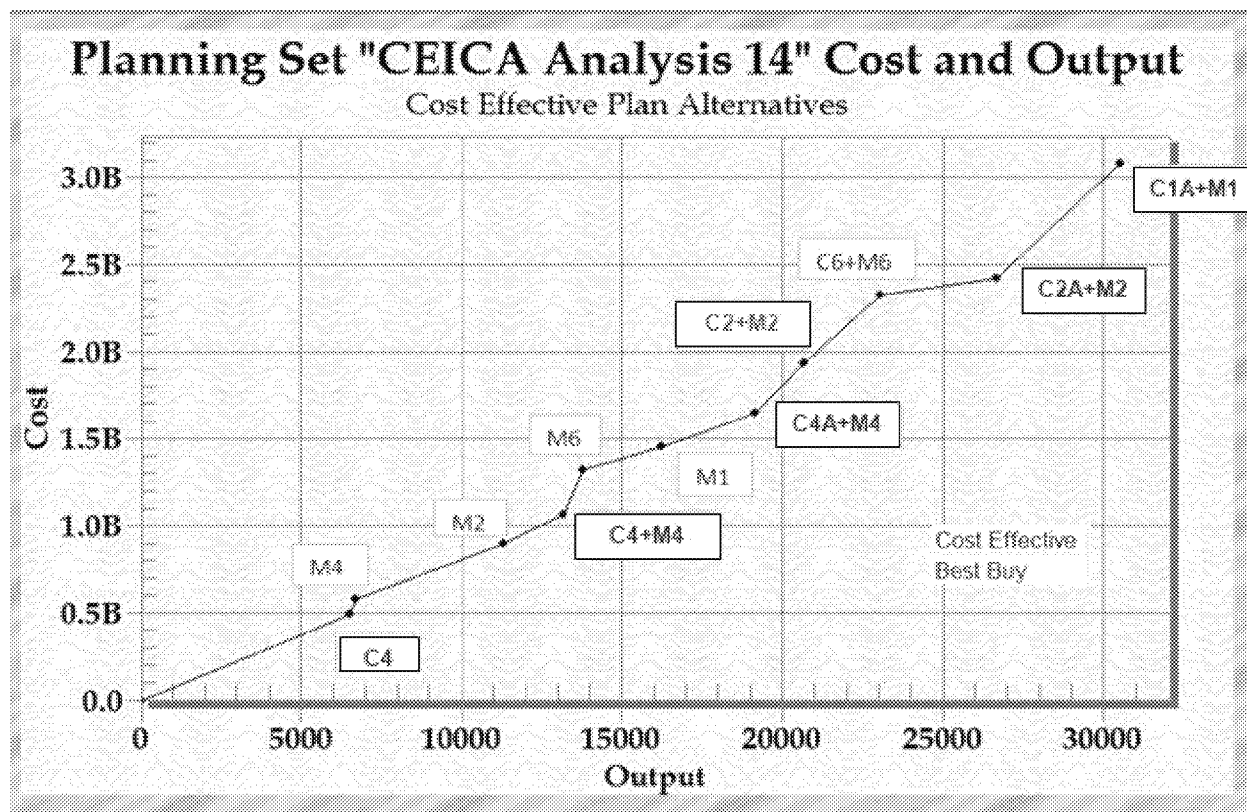


Figure 11. CE/ICA Analysis Using Low Navigation Cost.

The number of H&S, MC, and SP measures varied depending on the plan scale and emphasis. The six comprehensive plans were estimated to produce between 10,716 and 30,547 acres. Their costs range from \$1.38 Billion and \$2.9 Billion.

As part of this evaluation, plans with and without Alternative A (H&S measure #7) were compared. This one feature has a great potential to provide significant environmental benefits (5,969 acres, or approximately 2,400 AAHUs) even as a stand-alone plan.

When the cost effective and best buy plans are compared, the only plans that contain H&S measure #7 are towards the top of the curve. Plans 1 and 2 are the only comprehensive plans that contain Alternative A that are Best Buys. Plan 4 is a cost effective plan. Plan 4 without Alternative A is not only a cost effective plan, but it is the first comprehensive plan that is a Best Buy. For these reasons, Plan 4 without Alternative A is recommended as the NER TSP for the Southwest Coastal Feasibility Study.

NER 10.0 Identifying a Tentatively Selected Plan

- Results of CE-ICA analysis indicate Alternative C4+M4, Entry Salinity Control without alternative A, is the NER TSP.
- Dividing the original plans into basin sub-components provided additional incrementalization in the CE-ICA analysis.

- Alternative A, Stand alone Entry Salinity Control (H&S #7), displays the potential to provide significant environmental benefits, however:
 - ▶ Adequate evaluation of potential navigation impacts has not yet taken place.
 - ▶ Applying both low and high preliminary ROM estimates of navigation impacts eliminated alternative A from the cost efficient frontier.
 - ▶ Cost effective / Best Buy comprehensive plans containing alternative A exist only on the upper most portion of the cost efficient frontier.



Figure 12. Alternative 4 Calcasieu-Sabine Basin.



Figure 13. Alternative 4 Mermentau/Teche-Vermilion Basins

- Results are consistent in indicating that all variations of plan 4, Entry Salinity Control, or its components, with or without alternative plan A, are at a minimum cost effective. Figures 12 and 13 show the details of the draft NER TSP, Alternative 4.

Description of the Draft NER Tentatively Selected Plan.

- Nine marsh features to create 8,579 acres and nourish 4,026 acres, resulting in net acres of 8,714.
- Three hydrologic and salinity control measures create 3,167 net acres.
- Two shoreline protection measures span 27,461 linear feet and resulting in 1,314 net acres.
- Preservation of the historic Sabine oyster reef located near Sabine Pass.
- Chenier reforestation program on 1,412 acres in Cameron and Vermilion parishes.
- The preliminary cost of the NER TSP is estimated at \$1.064 billion.

11.0 Timeline

NEPA Scoping Meetings were held between January and April 2009; a Feasibility Scoping Meeting occurred in June 2010; the Alternatives Milestone was finalized on June 19, 2013.

28 Oct 2013	TSP Milestone
28 Feb 2014	Agency Decision Milestone
30 Jun 2014	Final Report Milestone
23 Aug 2014	State and Agency Review Complete
30 Sep 2014	Chief's Report Milestone

*Frequent in-progress reviews will be held to coordinate the study with the vertical team.